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None

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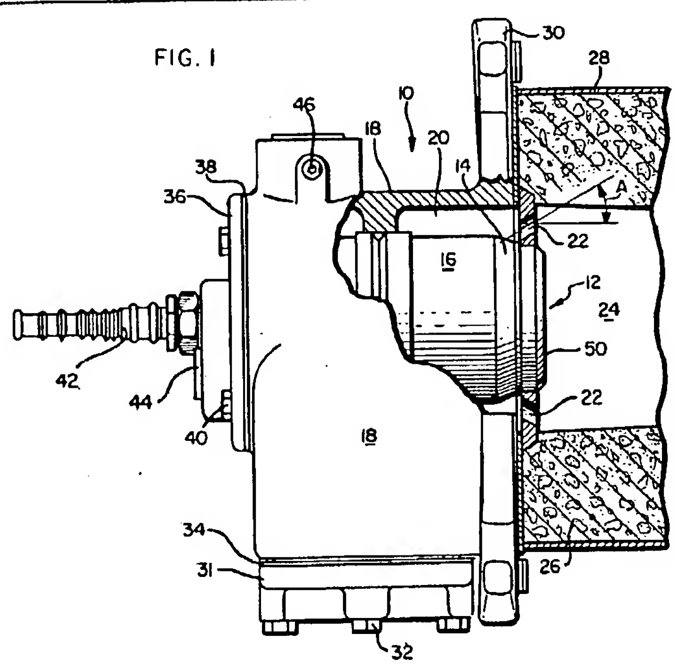
(54) Oxygen enriched burner flame

(57) A centrally disposed stream of gaseous fuel is provided at a pressure sufficient to direct the flame in a longitudinal direction, and a multiplicity of streams of oxygen-enriched air (or oxygen) in preferably a substantially stoichiometric amount are disposed about the stream of fuel and at a radial angle selected from approximately +20° to −20°, diverging from or converging towards, the longitudinal axis of the gaseous fuel stream. Next, the streams of gaseous fuel and oxygen enriched air are mixed. Finally, the mixture is combusted to form a sustainable flame having a zone of reduced temperature surrounding the flame to burn the gaseous fuel efficiently and to form relatively low levels of noxious combustion products therefrom. The oxygen-enriched air may contain up to 35% oxygen, and is fed through angled apertures 22 in an orifice plate 12 surrounding a fuel nozzle 16.

FIG. I



The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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FIG. 1

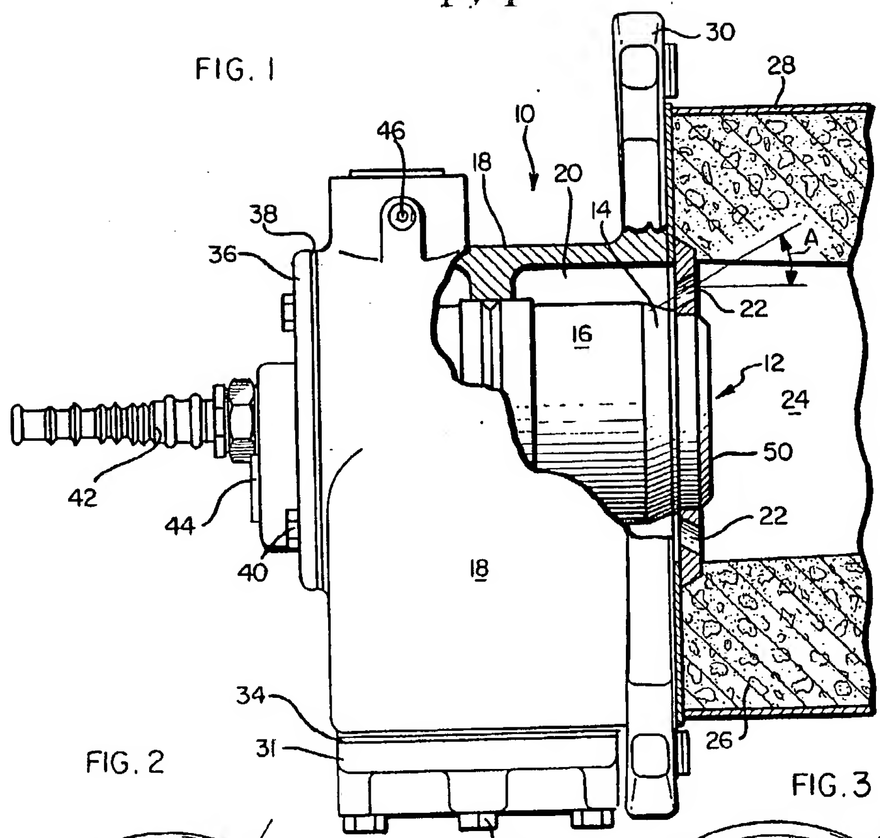


FIG. 2

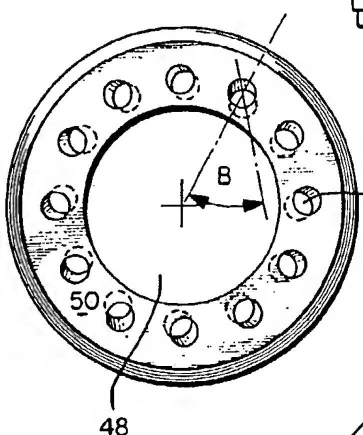


FIG. 3

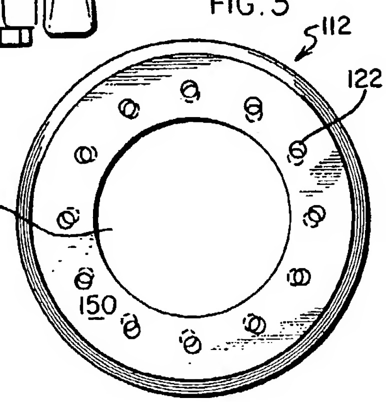
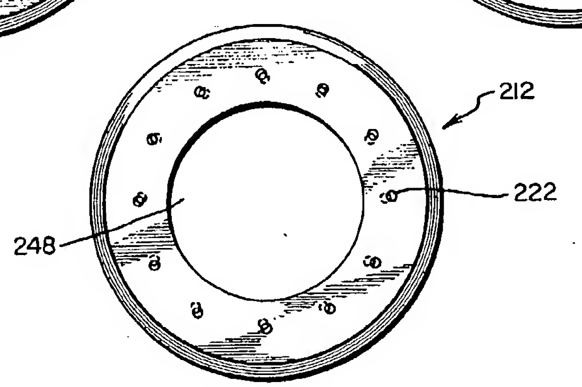


FIG. 4



SPECIFICATION

Improved method of providing oxygen enriched flame

BACKGROUND OF THE INVENTION

The present invention is directed to methods of providing heat, and more particularly to improved methods of providing efficient heating and at reduced costs by means of the direct burning of a gaseous fuel by means of oxygen enriched air streams.

The prior art has provided various types of burners of the most usually efficient heating of air for direct transfer of heat such as in an oven, and for the heating of liquids, such as may be contained within a boiler for indirect transfer of such heat. Some of such prior art heating mechanisms have used stoichiometric mixtures of various fuels, including for example gaseous fuels, with ambient air. However, some such burner mechanisms have had excessive flame temperatures, and flame shapes which have resulted in shock to the most generally necessary refractory block, which block has served as a sleeve for containing such flame in order to maintain the flame as a sustainable entity. Usually, a more durable material could not be used as and for the block because of the high temperatures of such prior art flame containing structures. Also some of such prior art burner mechanisms further have been relatively inefficient in burning the gaseous fuel and have created excessively high combustion products including NO and NO_2 (hereinafter sometimes designated as NO_x).

In view of the deficiencies and disadvantages of prior art burners, it is an object of the improved methods of the present invention to provide improved methods which do not require the use of a refractory block, but instead may utilize a metal sleeve in order to avoid contamination of the flame, and thereby the material being heated, and also in order to resist fracture from inadvertent impact.

It is a further object of the improved methods of the present invention to provide for levels of from at least approximately 35% oxygen to 100% oxygen enrichment, which levels yield a more efficient flame and at substantially lower combustion product levels.

It is yet further an object of the improved methods of the present invention to provide oxygen enrichment of the air stream and to do so by twisting the air stream at a velocity, pressure, angle of convergence or divergence, and at an angle of twist sufficient to shape a flame to create a zone of reduced temperature within the block, which in turn materially reduces block shock, but while maintaining efficient burning and substantially reduced combustion products.

It is also an object of the improved methods of the present invention to maintain the same isotherms within a burner structure as may be present with the utilization of ambient air, but to do so at a reduction of the gaseous fuel of approximately 15%, while at the same time maintaining reduced NO_x emissions.

The presently improved methods are especially adaptable in plants utilized for the production of aluminum, which facilities produce 35% oxygen enriched air as a by product of such aluminum production. The improved methods of the present invention also may find special application in circumstances wherein an exceedingly clean flame is necessary, such as in the heating of glass and other similar applications.

These and other objects of the improved methods of the present invention will become apparent to those of ordinary skill in the art upon review of the following summary of the invention, brief description of the drawing, detailed description of the preferred embodiments, including exemplary embodiments, appended claims, and accompanying drawing.

SUMMARY OF THE INVENTION

The improved methods of the present invention of providing efficient and reduced cost heating are accomplished by means of burning a preferably gaseous fuel directly, and doing so in the environment of oxygen enriched air. Specifically, a centrally disposed stream of such gaseous fuel, having a longitudinal axis and delivered at a pressure sufficient to direct the gaseous fuel in the longitudinal direction, is provided. A multiplicity of streams of oxygen enriched air preferably in stoichiometric amount is provided, and such streams are disposed, in transverse cross-section, in a circular array about the stream of gaseous fuel. Such gaseous streams are disposed for flowing in streams which are radially angled at approximately from +20° to −20° in divergence from or convergence towards the longitudinal axis of the gaseous fuel stream.

In the next step of the methods hereof, the stream of gaseous fuel and oxygen enriched air are mixed. Finally, the mixture is combusted to produce a sustainable flame, and within a block of shielding the flame, such flame having a zone of reduced temperature surrounding the flame, thereby to burn the fuel efficiently and to maintain relatively low levels of combustion products.

The improved methods of the present invention will be better understood with regard to the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The improved methods of providing combustion of a gaseous fuel in an oxygen enriched environment may be carried out by means of the exemplary apparatus shown in the Figs., and in which:

Figure 1 is a partially cut away cross-sectional and fragmented side view of a burner for carrying out the methods of the present invention, such burner including an orifice plate having for example an angle A of divergence from the longitudinal axis of the gaseous stream, a nozzle, an ignitor spark shield, a back plate with a gasket separating the back plate from the nozzle body, further having a spark ignitor subassembly disposed at the back portion of the nozzle body, and with the truncated and cross-sectional block assembly held by block holding frame means disposed at the front portion of such nozzle body;

Figure 2 is a front view of one preferred embodiment of an orifice plate, as shown in Fig. 1, and showing an illustrative angle of twist at angle B thereof with the plurality of orifices disposed radially in spaced array about the centrally disposed gaseous fuel conduit means, and being suitable for stoichiometric burning in ambient air containing 20.8% oxygen;

Figure 3 is a front view of an alternative embodiment of an orifice plate suitable for carrying out certain other embodiments of the improved methods of the present invention, and showing such angled and diverging orifices being one-half the diameter of those shown in the embodiment of Fig. 2, and suitable for use with oxygen enriched air streams containing 22.8% oxygen; and

Figure 4 is a front view of a further alternative embodiment of an orifice plate suitable for carrying out further embodiments of the improved methods of the present invention, and showing the angled and diverging orifices at approximately one-quarter the diameter of those of the embodiment of Fig. 2, and suitable for use with oxygen enriched air streams containing approximately 35% oxygen.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The improved methods of the present invention are directed towards providing efficient and reduced cost heating by means of direct burning of fuels including gaseous fuel in preferred embodiments, and in a stream of oxygen enriched air, which may have varying amounts of oxygen ranging from ambient air with approximately 20.8% oxygen air streams, to 35% oxygen air streams, and further to 100% oxygen streams. Specifically, such improved methods of the present invention include the initial step of providing a centrally disposed stream of gaseous fuel which has a longitudinal axis and is delivered at a pressure sufficient to direct the gaseous fuel in such longitudinal direction. A multiplicity of streams of oxygen enriched air are provided, and are disposed in transverse cross-section in a preferably circular spaced array about the stream of gaseous fuel, and flowing in streams which are radially angled in divergence or convergence at approximately +20° to −20° with respect to and respectively away from or towards the longitudinal axis of the gaseous fuel stream. The result is to direct the streams of oxygen enriched air in a plurality of paths around the centrally disposed stream of gaseous fuel. Such respective streams of fuel and oxygen enriched air are mixed, and are combusted to provide a sustainable flame having a zone of reduced temperature surrounding the flame, thereby to burn such gaseous fuel efficiently and to form relatively low levels of noxious combustion products therefrom, including reduced levels of NO_x.

In some preferred embodiments, the improved methods of the present invention include oxygen enrichment of up to approximately 35% oxygen. In yet further preferred embodiments, pure oxygen may be used, in which case orifice openings having approximately one-fifth the diameter of those useable with ambient air may be provided.

Various delivery pressures of the stream of gaseous fuel may be utilized, and are determinable by those of ordinary skill in the art without the necessity for undue experimentation, and as taught by the examples of specification hereof. The same is true with respect to the required delivery pressure of the streams of air utilizable therewith, and as are further set forth in the examples illustrating preferred and alternative embodiments, *supra*.

The stream of gaseous fuel may preferably be generally circular in transverse cross-section. The streams of oxygen enriched air surrounding the longitudinal axis of the gaseous fuel stream may be twisted. Such twisting may comprise the disposing of the streams of oxygen enriched air at an angle of approximately 0° to 40° with respect to the longitudinal axis of the stream of gaseous fuel. Such twistings of the streams of oxygen enriched air may form a plurality of spiral streams in preferred embodiments disposed about the centrally disposed gaseous fuel stream. The cross-sectional diameter of the streams of gaseous fuel and the respective diameters of the plurality of surrounding streams of oxygen enriched air may be selected to render the combustion thereof substantially stoichiometric, according to standards known to those having ordinary skill in the art, and as are set forth in the following examples of preferred and alternative embodiments.

The respective pressures and respective diameters of the gaseous fuel stream and the multiplicity of streams of oxygen enriched air are selected in preferred embodiments to maintain

substantially constant isotherms using the oxygen enriched air streams, as compared to isotherms in a burner apparatus in utilizing ambient air in such a burner for combustion of the gaseous fuel.

The improved methods of the present invention may further comprise radially confining the sustainable flame. Such radial confining may preferably be accomplished by means which are free of refractory materials to prevent particles of any such refractory material from contaminating the sustainable flame, and/or thereby the material being heated by such flame. Such radial confining means may comprise a metallic sleeve. Also, in other preferred embodiments, the radial confining may be accomplished by means of a refractory material sleeve where the heating purpose is indirect and/or other means are present for reducing contamination of the item to be heated.

In some of the improved methods of the present invention as set forth in illustrative examples hereof, the temperature of the sustainable flame in some embodiments thereof may be reduced as as compared to combustion within ambient air.

Referring now to the drawing, and to Fig. 1 in particular, the improved methods of providing combustion of the gaseous fuel in an oxygen enriched environment may be carried out by means of the exemplary apparatus shown in the Figs., although other apparatus for carrying out such inventive methods may be devised by those skilled in the art.

Fig. 1 depicts in partially cross-sectional and fragmented side view a burner generally 10 for carrying out the present invention. Burner 10 includes an orifice plate generally 12 disposed at the front portion 14 of nozzle 16. Nozzle 16 is disposed within a nozzle body 18 containing an oxidizing gas conduit portion 20 for transmittal of oxidizing gas from an external source and preferably through an adjustable orifice cock (not shown). Also referring to Fig. 2, such oxidizing gas is transmitted through orifice 22 in orifice plate 12 in a diverging stream shown as angle A in Fig. 1, into the central bore 24 of refractory block 26. Such refractory block 26 is supported by means of block frame 28 held by nozzle body flange 30. Such nozzle body 18 may further include an inlet flange 31 attached to nozzle body 18 by means of suitable bolts 32 and sealed thereto by means of gasket 34. Similarly, a nozzle body back plate 36 is sealingly attached by means of gasket 38 and bolts 40 to nozzle body 18. Disposed onto back plate 36 is a spark ignitor assembly 42. A sight glass 44 may also be provided for viewing the interior of nozzle 16. Also, a hollow pipe plug 46 may be provided for access in to nozzle body 18.

Referring now to Fig. 2 in particular, which depicts a front view of the embodiment of orifice plate 12 as shown in Fig. 1, for use with ambient air, an angle B of twist of the plurality of orifices 22 is illustrated. Such orifices 22 are disposed radially in spaced array about a centrally disposed gaseous fuel conduit 48. The surface 50 of orifice plate 12 may preferably be planar, as shown, although other arrangements are contemplated.

Fig. 3 illustrates an embodiment of an orifice plate 112 suitable for carrying out certain other embodiments of the improved methods of the present invention, and showing such orifices 122 being approximately one-half the diameter of those shown in the embodiment of Fig. 2, and suitable for use with plus 2% oxygen enriched air streams. Centrally disposed gaseous fuel conduit 148 is shown. The plate surface 150 is likewise preferably planar, and such orifices 122 are likewise diverging at angle A and twisted at angle B.

Similarly, Fig. 4 illustrates a front view of a further embodiment of an orifice plate 212 suitable for carrying out a further embodiment of the improved methods of the present invention. Orifice plate 212 likewise includes a centrally disposed gaseous fuel conduit 248, and further includes angled and diverging orifices 222 at approximately one-quarter the diameter of those of the embodiment of Fig. 2 for ambient air. Such embodiment of orifice plate 212 of Fig. 4 is suitable for use with an approximately 35% oxygen enriched air stream.

As referred to in Exhibit I, six different loci of temperature measurement were selected for inclusion in the following examples of illustrative embodiments of the methods of the present invention, are are designated respectively as T_1, T_2, T_3, T_4, T_6, and T_6. The location of these loci of temperature are identified, as follows:

T_1—On the top outside surface of refractory block 26 near the exit end, which is opposite flange 30;

T_2—near T_1 on the side/top outside surface of refractory block 26 and approximately 45° degrees from the vertical;

T_3—on the outside surface of refractory block 26 near T_2 and approximately 90 degrees from the vertical;

T_4—buried approximately 1/4" in the front face of refractory block 26 at the top center portion of such face;

T_5—buried approximately 1/4" in the front face of refractory block 26 at the bottom center portion of such face; and

T_6—on the inside lateral surface of refractory block 26 near the exit end, which is opposite flange 30.

Working examples of various embodiments of the improved methods of the present invention have been conducted and are set forth in columnar form in Exhibits I and II, *infra*.

In preferred embodiments, the burner 10 may be a 1-1/2 inch burner, 2 inch burner, 3 inch burner, 4 inch burner, 6 inch burner or other sizes of burner. The material for refractory block 26 may preferably comprise a fuseable ceramic material having large temperature withstanding capacity and/or other materials. Where a ceramic block 26 is utilized, the initial diameter of central bore 24 thereof may vary from 3-1/4 to 5-1/2 inches for 1-1/2 to 4 inch burners respectively. Such a refractory block 26 may be at least 9-1/4 inches to 13 inches in length. These and other dimensions are not deemed to be critical and may be suitably varied.

The basic and novel characteristics of the improved methods of the present invention will be readily understood from the foregoing disclosure by those skilled in the art. It will become readily apparent that various changes and modifications may be made in the conducting of the improved methods of the present invention as set forth hereinabove without departing from the spirit and scope of the invention. Accordingly, the preferred and alternative embodiments of the present invention set forth hereinabove are not intended to limit such spirit and scope in any way.

EXHIBIT I

Flame Tests Using 2" KINEMAX™ Burner[1]
Using Natural Gas

	Gas Volume Cubic Feet Per Hour	AIR Pressure (Water Inches Column)	GAS Pressure (Water Inches Column)	Percent O_2 in Body	Percent O_2 in Furnace	Block Temp. T_1 (F.)	T_2 (F.)	T_3 (F.)	T_4 (F.)	T_5 (F.)	Exit Port T_6 (F.)	Flame Temp. (F.)	Visible Flame Length (in Inches)	Flame Diam. (in Inches)	Flame Color	Firing Time (In Minutes)
FURN.	600	7	1.5	20.8	2	-	-	-	-	-	-	-	14	6	Blue	-
TEST	1000	6	4.0	35	2	-	-	-	-	-	-	-	36+	4	White	-
OPEN	1000	22.5	3.6	20.8	-	98	123	112	363	351	595	3100	14	6	Blue	15
AIR	1000	7.5	4.0	35.	-	132	159	164	508	437	770	2650	24	6	White	15
↑	1000	22.5	3.6	20.8	-	120	162	152	401	375	628	3150	14	6	Blue	30
	1000	7.5	4.0	35	-	232	246	267	557	480	765	2650	42	6	White	30
	1000	22.5	3.6	20.8	-	139	188	185	422	390	643	3150	14	6	Blue	60
	1000	6.5	4.0	35	-	247	262	285	568	486	760	2650	42	6	White	60
	600	8.0	1.5	20.8	-	165	234	240	644	478	1100	3100	24	5	Blue	10
	600	4.0	1.5	35	-	260	271	298	572	506	755	2700	30	6	White	10
	200	1.0	.2	20.8	-	198	279	312	724	696	1275	2950	18	4	Blue	15
	200	1.5	.2	35	-	269	294	319	585	559	816	3150	1	4	White	15
	100	.5	.1	35	-	288	310	338	604	603	838	3200	18	4	Bl/Wh	5
↓	25	.1	0	35	-	300	320	340	540	540	750	3200	6	1	Bl/Wh	10

1. Trademark of Maxon Corporation; Muncie, Indiana.

EXHIBIT II

AMBIENT AIR and O_2 ENRICHED COMPARISON USING
6" KINEMAX" BURNER SERIES "G"
(FURNACE O_2 - 2%)

MRV	Gas Volume (Cubic Feet Per Hour)	Air Pressure (Inches Water Column)	Gas Pressure (Inches Water Column)	% O_2 BURNER BODY			MRV	Gas Volume (Cubic Feet Per Hour	Air Pressure (Inches Water Column)	Gas Pressure (Inches Water Column)	% O_2 BURNER BODY	PSI O_2 H.G. TUBE					FURNACE PRE .05 Inc Water Co
PILOT	200	.1	.004	20.8			PILOT	200	.1	.004	35	.05					
MINIMUM	ON RATIO 500	.1	.05	20.8			MINIMUM	800	.1	.1	35	.1					
1	1400	.8	.3	20.8			1	2400	.8	.6	35	.2					
2	1900	1.5	.7	20.8			2	3800	1.5	1.8	35	.6					
3	2800	3.1	1.4	20.8			3	4900	3.1	3.4	35	1.					
4	4000	6.2	1.6	20.8			4	6100	6.2	5.3	35	1.5					
5	4900	9.5	3.4	20.8			5	8000	9.5	8.5	35	2.3					
6	5800	13.	4.8	20.8			6	9300	13.	10.	35	3.2					
7	6400	16.	6.1	20.8			7	10400	16.	12.	35	4.2					
8	7150	20.	7.1	20.8			8	11600	20.	15.	35	5.1					
9	7670	23.	7.7	20.8			9	12400	23.	22.	35	6.					
10	8000	25.	8.1	20.8			10	13000	25.	25.	35	6.8					
MAXIMUM	8300	27.	8.5	20.8			MAXIMUM	13500	26.4	26.4	35	8.					

CLAIMS

1. An improved method of providing efficient and reduced cost heating by means of direct burning of a gaseous fuel, said improved method comprising the steps of:

providing a centrally disposed stream of gaseous fuel having a longitudinal axis and delivered at pressure sufficient to direct the gaseous fuel in a longitudinal direction;

providing a multiplicity of streams of oxygen enriched air, disposed in transverse cross-section in a circular array about the stream of gaseous fuel, and flowing in streams radially angled approximately +20° to −20° with respect to the longitudinal axis of the gaseous fuel stream initially to direct the streams of oxygen enriched air in a plurality of paths around the centrally disposed stream of gaseous fuel;

mixing the stream of gaseous fuel and oxygen enriched air; and

combusting such mixture to provide a sustainable and shaped flame having a zone of reduced temperature surrounding the flame, to burn such gaseous fuel efficiently and to form reduced levels of noxious combustion products therefrom.

2. The improved method of claim 1 wherein the oxygen enrichment of the air stream is elevated up to approximately 35% oxygen.

3. The improved method of claim 1 wherein the oxygen enrichment of the air stream is pure oxygen.

4. The improved method of claim 1 wherein the stream of gaseous fuel is generally circular in transverse cross-section.

5. The improved method of claim 1 further comprising twisting the streams of oxygen enriched air around the longitudinal axis of the gaseous fuel stream.

6. The improved method of claim 5 wherein said twising comprises disposing the streams of oxygen enriched air at an angle of approximately 0–40° with respect to the longitudinal axis of the stream of gaseous fuel.

7. The improved method of claim 5 wherein such twisted streams of oxygen enriched air form a plurality of spiral streams disposed about the centrally disposed gaseous fuel stream.

8. The improved method of claim 1 wherein the cross-sectional diameter of the streams of gaseous fuel and the respective diameters of the plurality of surrounding streams of oxygen enriched air are selected at a selected pressure to render the combustion thereof substantially stoichiometric.

9. The improved method of claim 1 wherein the respective pressures and respective diameters of the gaseous fuel stream and the multiplicity of streams of oxygen enriched air are selected to main substantially constant isotherms as compared to combustion of the gaseous fuel in ambient air.

10. The improved method of claim 1 further comprising radially confining the sustainable flame.

11. The improved method of claim 10 wherein such radial confining is accomplished by means free of refractory materials to prevent particles of refractory material from contamining the sustainable flame.

12. The improved method of claim 11 wherein the radial confining means comprises a metallic sleeve.

13. The improved method of claim 12 wherein such radial confining is accomplished by refractory material sleeve means.

14. The improved method of claim 1 wherein the temperature of the sustainable flame is reduced as compared to combustion with ambient air.

15. A method of providing an oxygen enriched flame substantially as herein described.

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ABSTRACT:

A centrally disposed stream of gaseous fuel is provided at a pressure sufficient to direct the flame in a longitudinal direction, and a multiplicity of streams of oxygen- enriched air (or oxygen) in preferably a substantially stoichiometric amount are disposed about the stream of fuel and at a radial angle selected from approximately +20 DEG to -20 DEG , diverging from or converging towards, the longitudinal axis of the gaseous fuel stream. Next, the streams of gaseous fuel and oxygen enriched air are mixed. Finally, the mixture is combusted to form a sustainable flame having a zone of reduced temperature surrounding the flame to burn the gaseous fuel efficiently and to form relatively low levels of noxious combustion products therefrom. The oxygen- enriched air may contain up to 35% oxygen, and is fed through angled apertures 22 in an orifice plate 12 surrounding a fuel nozzle 16.
<IMAGE>